UV Scanner

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Examination of documents under ultraviolet radiation has become an important aid in determining possible modifications, substitutions, and/or alterations to documents. Forensic analysis of documents often involves creating illustrations of findings. It has not been uncommon to use ultraviolet film for this purpose. Ultraviolet film requires careful handling, special illumination, and occasional trial and error to obtain a good result. In addition, use of ultraviolet film is time consuming and expensive. In late 2000, experiments were undertaken to change a flatbed scanner into an ultraviolet (UV) scanner. The light tubes in several flatbed scanners were replaced, first with a short-range UV tube, then a long-range UV tube. Ultimately, excellent focused images resulted using 1 particular scanner. The UV scanner operates conventionally, although it acts on the radiation, intensity, and frequency band of the tube installed.

Introduction

History of Ultraviolet Radiation and Fluorescence

Johann Wilhelm Ritter (1776-1810) was a somewhat controversial scientist best known for his discovery in 1801 of ultraviolet radiation by chemical means (Abramovitz and Davidson, 2004). He was born in Samitz, Germany (now Chojnow, Poland). A year before, William Herschel had announced the existence of the infrared region, which extends past the red region of visible light. Ritter, who believed in the polarity of nature, hypothesized that there must also be invisible radiation beyond the violet end of the spectrum and commenced experiments to confirm his speculation. He began working with silver chloride, a substance decomposed by light, measuring the speed at which different colors of light broke it down. As a result, Ritter confirmed the common belief that violet light was more effective than red in decomposing silver nitrate. He demonstrated that the fastest rate of decomposition occurred with radiation that could not be seen but existed in a region beyond the violet. Ritter initially referred to the new type of radiation as chemical rays; however, the title *ultraviolet radiation* (UV) eventually became the preferred term.

Throughout his career, George Gabriel Stokes (1819-1903) emphasized the importance of experimentation and problem solving rather than focusing solely on pure mathematics (Abramovitz and Davidson, 2004). His practical approach served him well, and he made important advances in several fields—most notably hydrodynamics and optics. Stokes coined the term *fluorescence,* having discovered that fluorescence can be induced in certain substances by stimulation with ultraviolet light, thus formulating Stokes Law in 1852. Sometimes referred to as Stokes shift, this law holds that the wavelength of fluorescent light is always greater than the wavelength of the exciting light. An advocate of the wave theory of light, Stokes was one of the prominent 19th century scientists that believed in the concept of an ether-permeating space, which he supposed was necessary for light waves to travel.

Ultraviolet Light

Ultraviolet radiation, commonly abbreviated UV, propagates at frequencies just above those of violet in the visible light spectrum. Although the low-energy end of this spectral region is adjacent to visible light, ultraviolet rays at the upper end of their frequency range have enough energy to kill living cells and produce significant tissue damage (Abramovitz and Davidson, 2004). Examination of documents using radiation out of the frequency range of visible light has become a strong aid in criminal science, especially in determining possible erasures, modifications, and/or substitutions. Universally, UV is a common tool for currency and passport inspections.

UV radiation can be dangerous (American Academy of Ophthalmology, 2004). Without eye

Figure 1. Reproduction of a forged 10.000 Bolivares bank note with light vertical lines on the left caused by LED saturation by UV emissions.

protection, exposure can cause eye damage, including epithelium burning similar to eye burns caused by welding. Once a threshold dose has been exceeded, exposing the skin to UV light can lead to redness or burning. Finally, UV overexposure can cause cancer.

Ultraviolet Photography

Forensic document examination case files and/or reports often contain demonstrative charts relating to findings. It has not been uncommon to use UV photography in the preparation of demonstrative charts. UV photography requires special film (400-800 IS0 color), low-light illumination, and occasional trial and error to obtain a satisfactory result. Also, it is time consuming and costly. The examination of documents using radiations out of the frequency range of visible light has become a strong aid in questioned document examinations to determine possible erasures, modifications, and/or substitutions, particularly on documents representing values of any kind (checks, drafts, titles, etc.). Advances in imaging technology are reflected in devices such as the Foster & Freeman VSC series of video spectral comparators. Although these devices offer excellent quality, their high cost makes them inaccessible to some private experts.

Since 1997, this author has been conducting experiments using different digital capture systems and illumination in an effort to produce a low-cost and efficient system for the examination of documents using UV light. In late 2000, experiments were conducted to change a flatbed scanner into an UV scanner. The light tube in a flat scanner was replaced with short-range then long-range ultraviolet tubes.

Methods and Materials

Use of digital imaging technology in forensic document examination and the many obstacles associated with UV photography led to the idea of combining conventional digital flat scanning with UV light. To learn how luminescence was "captured" by a conventional scanner CCD, the original fluorescent tube in a scanner was exchanged first with a UV-A tube then a UV-B tube. Experiments were conducted on several models of scanner, including the Colorpage SP2X and the Genius (KYE). Hardware failures resulted immediately after changing the original tubes for UV tubes. Eventually success was achieved after assembling the following: Acer Flat Scanner Model 300F (6684), Mr. Light 8W FL8T5 BLB UV tube, Toshiba GL8 8W Germicidal UV tube, and a personal computer with Windows 98 and Adobe Photoshop 6.

Although the Acer scanner worked with the selected UV tubes, software errors related to the lamp heating caused calibration problems. Initially, red lines on images appeared after scanning (Figure 1). After noting that better results were obtained when the lamp and CCD sensors cooled down, a literature review and an Internet search were conducted to solve the problem of the sensors being affected by the lamp heat. It was concluded that the CCD absorbed electromagnetic energy and converted it to heat, which in turn affected its sensitivity.

Once a way was found to make the scanner work continuously, it was observed that scans made at low resolutions (75-150 dpi) prevented the CCD from capturing anything. This was mostly affected by the Preview function in Adobe Photoshop which works primarily with low resolution. After first scanning with the UV long-wave tube, images obtained were very dark, almost invisible. Image adjusting with the Auto Levels option in Photoshop yielded excellent results (Figure 2).

An important benefit of the UV scanner is that luminescence capture is safe. The examiner is protected by the scanner cover that blocks harmful radiations.

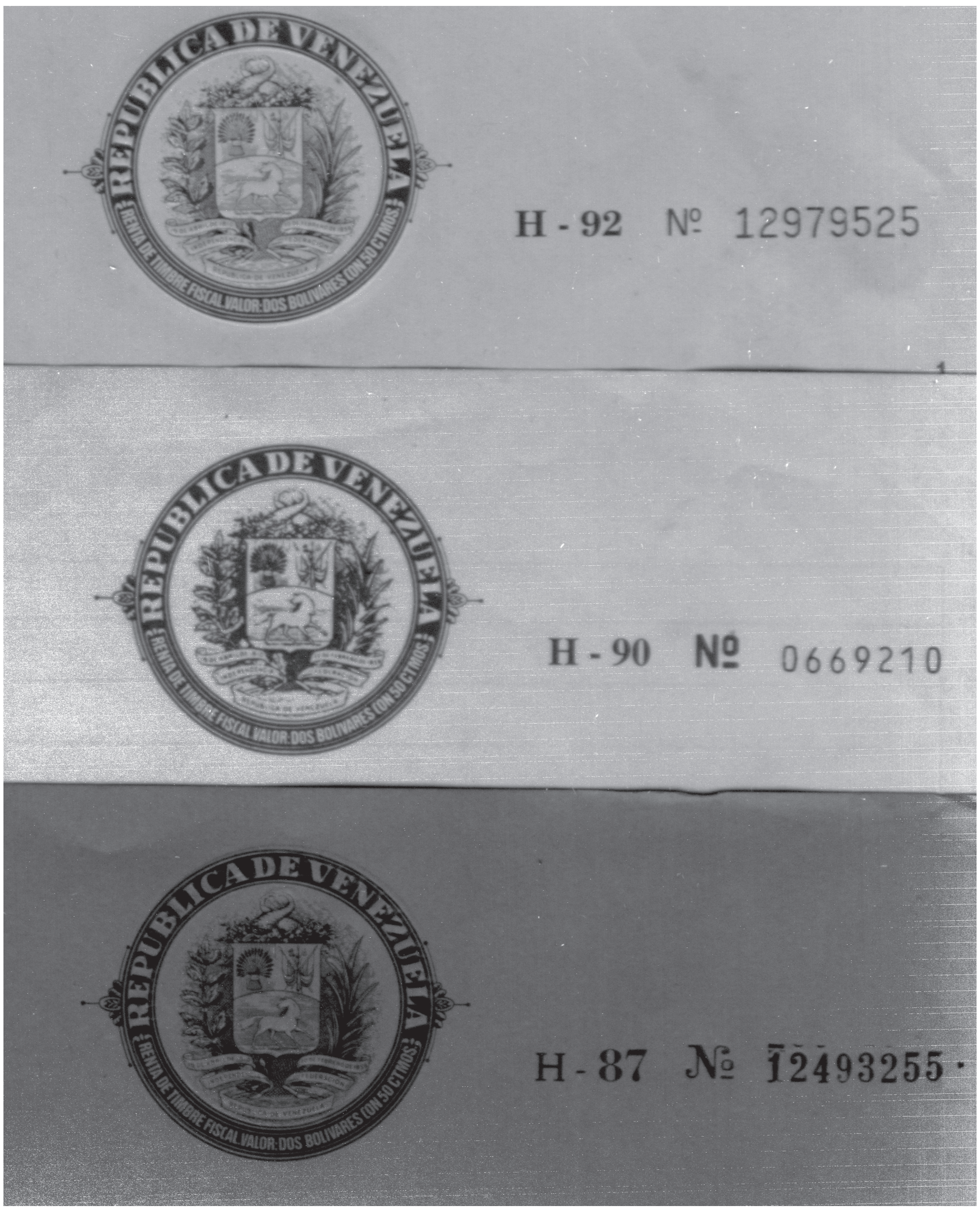

Figure 2. Image of 3 stationery papers acquired with UV scanner.

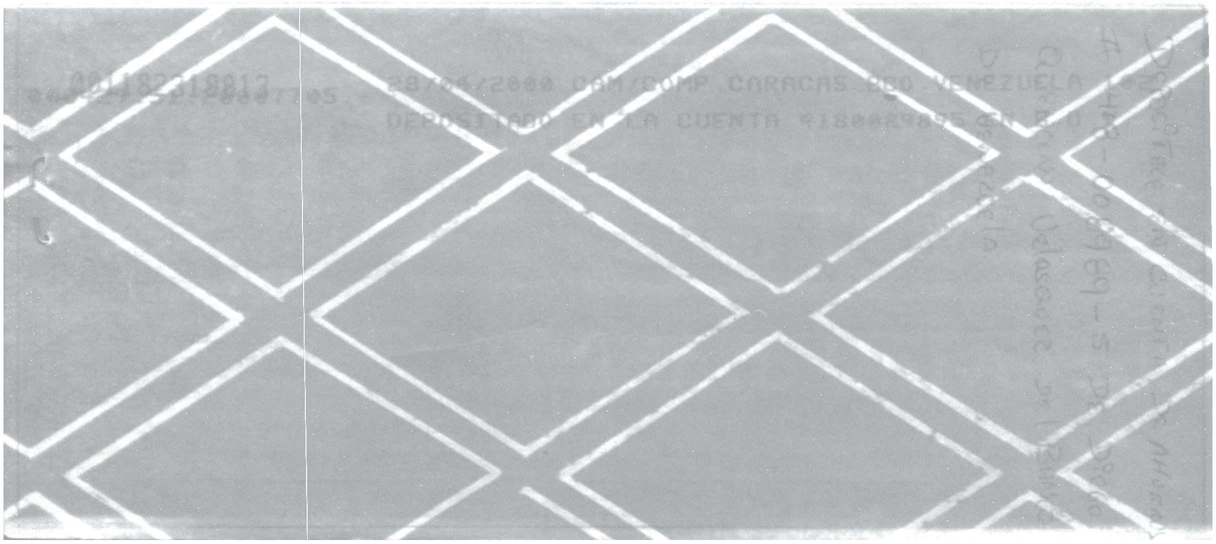

Figure 3. Fake watermark on the reverse side of a questioned check.

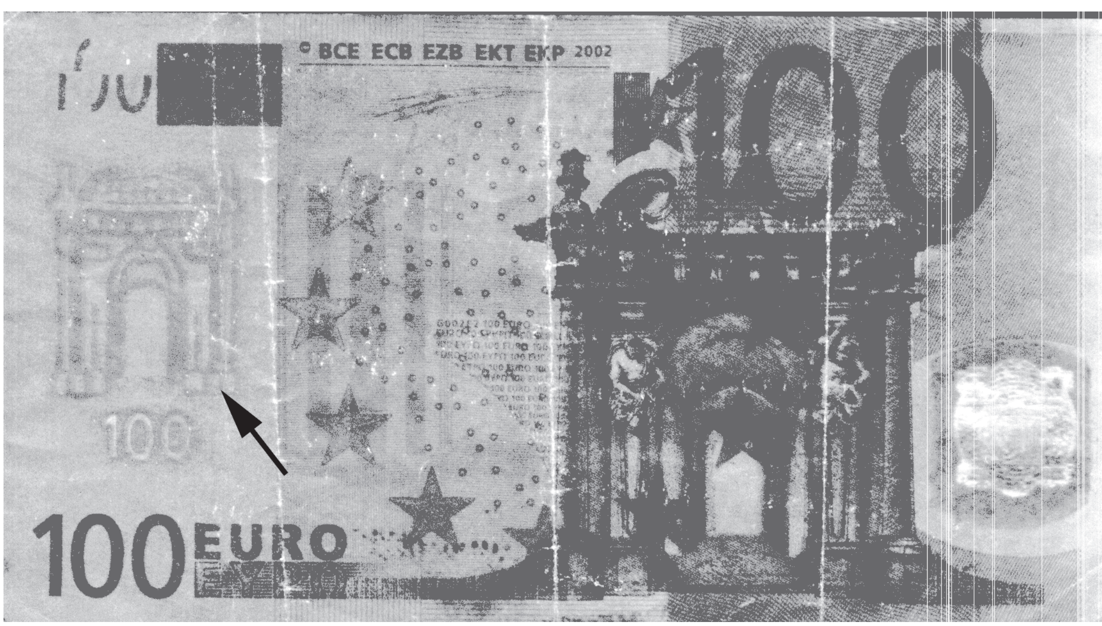

Figure 4. Fake watermark on a questioned 100 Euros banknote.

Discussion

Images created by the UV scanner (Figures 3 and 4) can be improved using Adobe Photoshop and rotating, adjusting, and duplicating before saving them in the required format. It was thought that this UV device could be improved with software created for forgery detection based on pre-established patterns of security elements that respond to UV radiation. Applications for this purpose are being developed. Once developed and patented, it is believed that this low-cost UV scanner (combined with filters) will be of assistance to the forensic document community.

Conclusion

Digital imaging technologies allow forensic experts to demonstrate their finding in a minimum amount of time. However, these technologies are not necessarily low in costs. A UV scanner has been developed that will be very cost effective. During the scanning process, the UV scanner operates conventionally, acting on the corresponding radiation, intensity, and frequency band as selected. A signal or a group of signals gathered by way of the scanner is processed in the computer and converted into visible images in the monitor. This scanner invention, which is currently in the patent pending stage, will provide a system that can acquire a direct digital image of suspect documents for fast comparison. Also, the UV scanner could be a partial solution for a reduction in laboratory costs associated with other equipment and/or film. Presently, improvements are being made to 2 prototypes.

References

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